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2012 Turtle Excluder Device Testing and Gear Evaluations

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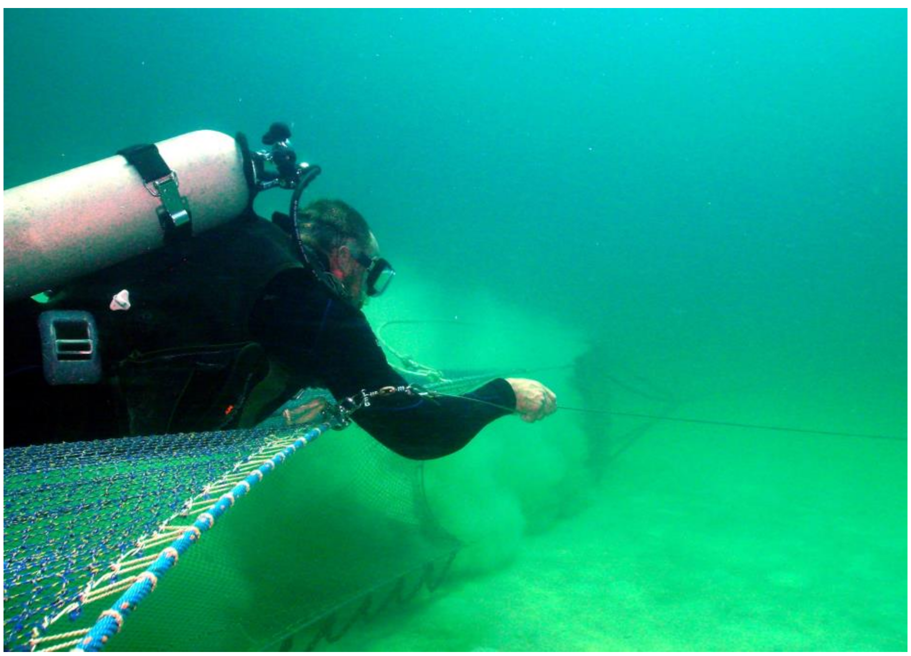

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NOTICE

This report should be cited as follows:
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The NOAA National Marine Fisheries Service (NMFS), Southeast Fisheries Science Center (SEFSC), Mississippi Laboratory, Harvesting Systems & Engineering Branch conducted fishing gear evaluations in Panama City, Florida from June 5 through June 20, 2012. Four separate projects were conducted: 1) evaluation of Turtle Excluder Devices (TEDs) in skimmer trawls; 2) evaluation of Cable TEDs in fish trawls; 3) sea turtle exclusion rate trials for TED component variations; 4) evaluation of Bycatch Reduction Devices (BRDs) in shrimp trawls. Skimmer trawl TED evaluations were conducted aboard two contracted commercial vessels. Divers evaluated three different size TEDs installed at various locations to determine optimum TED size and placement. Divers found that TEDs installed in skimmer trawls are very similar to TEDs installed in otter trawls with the same factors affecting their configuration and performance. Cable TED evaluations were also conducted aboard a contracted commercial vessel. Divers evaluated various configurations to improve performance of the Cable TED and found that the shape of the lead ring determined the shape of the TED flap. The Cable TED, which was designed as a top opening TED, was also evaluated in a bottom opening orientation. Divers found that the TED was poorly configured as a bottom opening TED and required major modifications to improve performance. Sea turtle exclusion rate trials were conducted aboard the NOAA/NMFS vessel *R/V Caretta*. This work was conducted to test variations in different components of existing shrimp trawl TED designs to determine their effect on sea turtle exclusion rates. Variations tested included TED angles, TED orientation, straight vs. curved deflector bars, and degree of overlap on double-cover flaps. A total of 163 two year old and 37 three year old captive reared loggerhead sea turtles (*Caretta caretta*) were utilized to complete this testing. All evaluations followed the small turtle testing protocol (Federal Register, Vol. 55, No. 195). Results indicate that sea turtle exclusion rates for high angle TEDs were lower when TEDs were installed in a bottom opening configuration. Exclusion rates were further reduced for high angle, bottom opening TEDs when configured with straight deflector bars. The *R/V Caretta* was also utilized to complete evaluations of two BRD designs. One was an industry prototype, the Burbank TED/BRD, which was similar to the original NMFS TED developed in the 1980s. The other was the certified Composite Panel BRD, which was evaluated in two configurations to examine clogging potential with locally obtained brown macroalgae, *Sargassum natans*. The Burbank TED/BRD had a good configuration with reduced water flow areas located at three locations within the device. The device was recommended for proof of concept testing to examine shrimp retention. The Composite Panel BRD was examined with the addition of a fish deflector cone installed in two different configurations behind the device. The standard two line attachment of the deflector cone was prone to clogging with algae, while an alternative one line attachment reduced clogging significantly.

INTRODUCTION

In June 2012, the NOAA National Marine Fisheries Service (NMFS), Southeast Fisheries Science Center (SEFSC), Mississippi Laboratory, Harvesting Systems & Engineering Branch conducted fishing gear evaluations in Panama City, Florida. This work was conducted in four phases.

1. Evaluation of Turtle Excluder Devices (TEDs) in skimmer trawls

2. Evaluation of Cable TEDs in fish trawls

3. Evaluation of TED components in shrimp trawls for sea turtle exclusion rates

4. Evaluation of various Bycatch Reduction Devices (BRDs) in shrimp trawls

Phase 1 – 5-6 June 2012 - This work was conducted by chartering two commercial skimmer trawlers including the 8.5 m (28 ft) *F/V SkyBaby* and the 19.8 m (65 ft) *F/V Captain Justin*. The purpose of these evaluations was to determine the best size, shape, and placement of a TED into both large and small skimmer nets.

Phase 2 – 7-9 June 2012 - This work was carried out to evaluate cable TEDs designed for use in larger trawls, which target finfish and use net reels to deploy and retrieve their nets. The work was conducted using Self-contained Underwater Breathing Apparatus (SCUBA) divers to make underwater observations, and then use that information to modify the TED. This portion of the project was conducted aboard the *F/V Captain Wick*, a 19.8 m (65 ft) stern trawler based in Pascagoula, Mississippi.

Phase 3 –11 -19 June 2012 - This work was done to test variations in the different components of existing shrimp trawl TED designs to determine the effect on sea turtle exclusion rates utilizing the small turtle testing protocol (Federal Register, Vol. 55, No. 195). These variations included TED angles, TED orientation, curvature of grid bars, and amount of overlap on double-cover flaps. For these tests, 163 two year old and 37 three year old loggerhead sea turtles (*Caretta caretta*), were obtained from the NMFS, SEFSC, sea turtle facility housed at the Galveston Laboratory in Galveston, Texas. This portion of the project was performed aboard the NOAA/NMFS vessel *R/V Caretta*, a 19.8 m (65 ft) twin rigged shrimp trawler.

Phase 4 – 20 June 2012 - This work was also conducted from the *R/V Caretta* and consisted of evaluations of two BRD designs. One was constructed by an East Coast net builder, Billy Burbank. The other was the certified Composite Panel BRD, which was evaluated in two configurations to examine clogging potential with locally obtained brown macroalgae, *Sargassum natans*.

PHASE 1 – SKIMMER TRAWL TED EVALUATIONS

Background

Skimmer trawls are used to target Penaeid shrimp (Penaeidae) throughout the southeastern U.S. as an alternative to traditional bottom-otter trawls. Due to the size, construction, and method of fishing, skimmer trawls have the benefit of operating in relatively shallow water (Hein and Meier 1995). Nets are attached to frames on each side of the vessel, which are lowered and pushed through the water column. The trawls are fished continuously with tail bags retrieved periodically to dump the catch.

Unlike standard bottom-otter trawls used to target shrimp, skimmer trawls have remained exempt from TED requirements since the implementation of TED regulations in the early 1990s. In lieu of the use of TEDs, skimmer trawl operations have been required to adhere to tow time limits (55 and 75 min, seasonal; Federal Register, Vol. 57, No. 234). Because skimmer trawl operations allow tail bags to be easily retrieved, tow time limits are a seemingly workable solution that can significantly decrease sea turtle bycatch and potential mortality. However, observations aboard commercial operations indicate that tow times are often exceeded and thus an increased risk of sea turtle mortality continues to exist in this fishery (Scott-Denton et al. 2006). Nevertheless, the industry has major concerns regarding the installation and use of TEDs in skimmer trawls. To address these concerns, Phase one of the 2012 gear evaluations intended to determine the best size and placement of TEDs for a given trawl size.

There are two major types of skimmer trawl frames used in the Gulf of Mexico (GOM) fishery along the Louisiana, Mississippi, and Alabama coasts. These are traditional "L-shaped" frames and modified "Kickout" frames. The "L-shaped" frames have a near 90^0 angle between the horizontal and vertical legs of the frame, while "Kickout" frames have angles of 135^0 or more. The "Kickout" frames are used to allow vessels to fish deeper water than traditional "L-shaped" frames. To complete this portion of the study, two vessels were contracted. One outfitted with "L-shaped" and another with "Kickout" frames.

Project Objectives

- Diver evaluations of two different styles of skimmer trawl: "L-shaped" and "Kickout" style frames
- Diver evaluations of various TED sizes, shapes, and placement in a 4.9 m (16 ft) skimmer trawl and a 7.6 m (25 ft) skimmer trawl

Methods

The first phase of the gear testing work was conducted aboard the 19.8 (65 ft) *F/V Captain Justin* and the 8.5 m (28 ft) *F/V Skybaby*. The *F/V Captain Justin* is a steel hulled skimmer trawler that operates out of Biloxi, Mississippi and employs a pair of 7.6 m (25 ft) skimmer trawls attached to 8.5 m (28 ft) "Kickout" skimmer frames. The *F/V Skybaby* is a steel hulled skimmer trawler that operates out of Grand Bay, Alabama and pushes a pair of 7.6 m (16 ft) skimmer trawls attached to 7.6 m (16 ft) by 3.7 m (12 ft) "L-shaped" skimmer frames. These vessels typically push trawls at speeds between 2.0- 3.0 kts, therefore our testing was done at 2.5 kts. Evaluations were conducted in the southeastern corner of St. Andrews Bay near Davis Point in water depths between 3 m (10 ft) and 5.5 m (18 ft) (Figure 1).

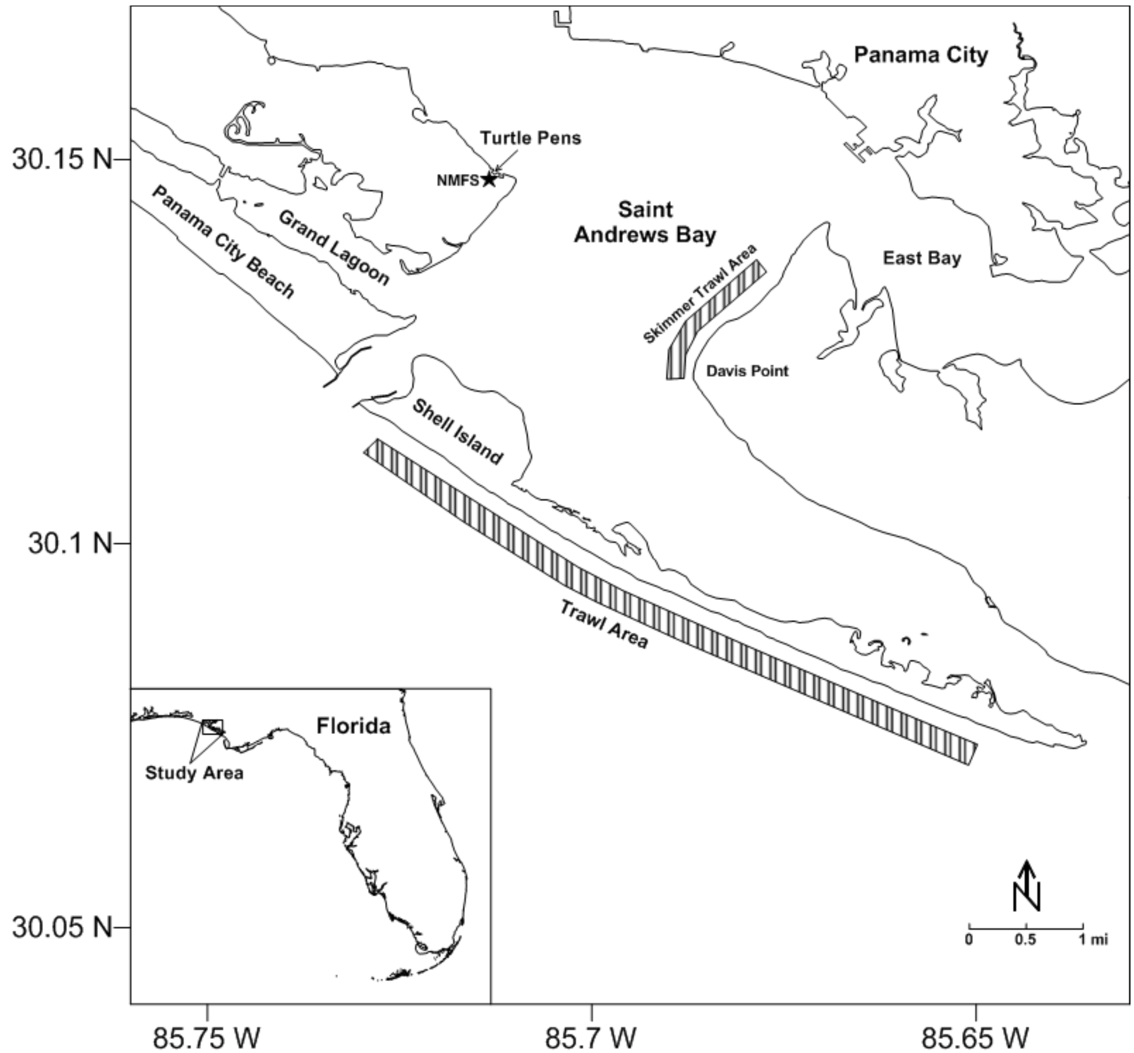

Figure 1. Map of Panama City, Florida and the study area including locations of the trawling area off Shell Island and turtle conditioning pens in St. Andrews Bay.

Results

A total of eight skimmer trawl dives were conducted to examine TED and trawl configurations. Three were conducted on the "L-shaped" frame vessel, while five were conducted on the "Kickout" frame vessel.

Kickout Frame

The first dive conducted on the "Kickout" frame skimmer trawl examined a mid-sized, super shooter style TED installed in a top-opening configuration with a double cover flap. Two 20.3 cm (8 in) hard plastic floats were added to each side of the TED. The captain of the vessel had an extension installed between the codend and the tail of the net that measured 150 meshes in circumference by 64 meshes long and was constructed of 41.3 mm (1 5/8 in) webbing. The TED was installed behind the extension on the first dive.

The trawl reduced to a small circle just ahead of the TED, where the TED extension was sewn to the tail of the net (Figure 2A). Divers commented that this portion of the trawl was small and that trawl and TED performance could be improved by enlarging this portion of the net. The way to achieve this effect would be to sew the TED directly to the tail of the net ahead of the 64 mesh extension. The small size of the trawl ahead of the TED resulted in the flap being tightly sealed down to a point just below the bent portion of the deflector bars (Figure 2B). The trawl opened relatively high and sloped down to the extension ahead of the TED with a smooth transition. The footrope of the trawl was close to the bottom and rode approximately 15.2 cm (6 inch) off the sea floor (Figures 2C and 2D).

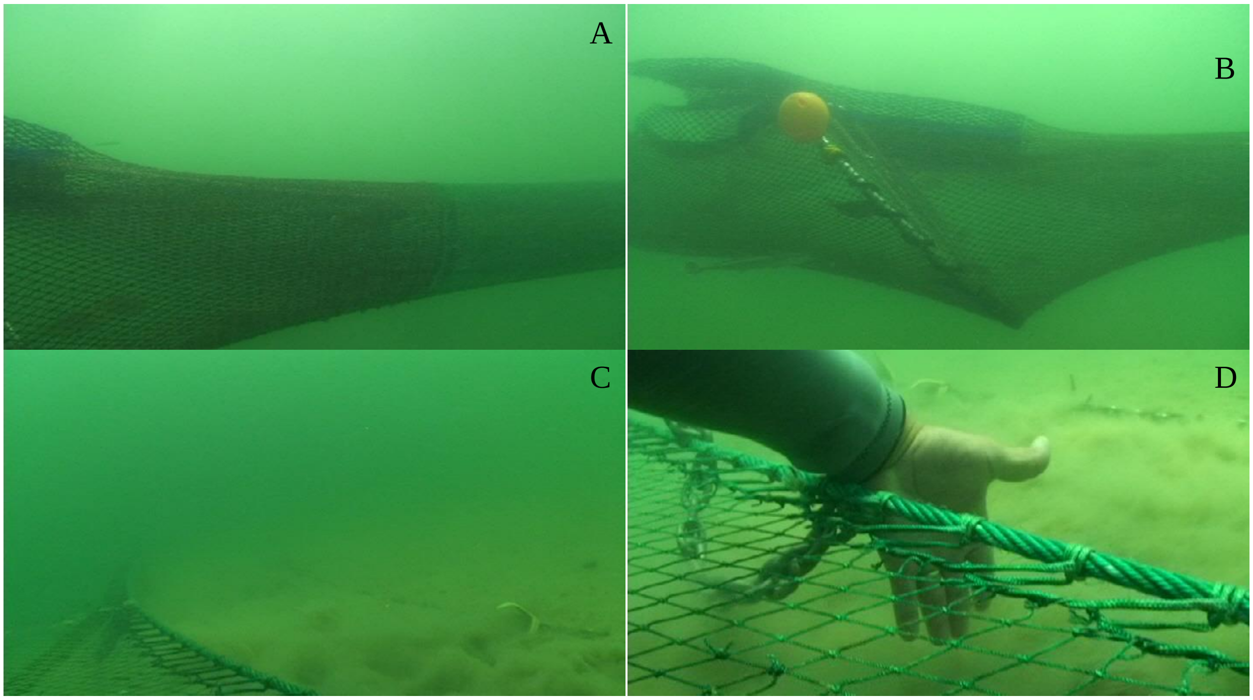

Figure 2. Photo grabs from video collected during 2012 "Kickout" frame skimmer trawl TED evaluations of a mid-size, super shooter installed in a top-opening configuration with double cover flap. A 64 mesh straight extension was installed ahead of the TED. A – transition between net and TED; B – profile of TED; C – side view of footrope; D – measuring footrope distance off sea floor.

The second dive was conducted with the same TED sewn directly to the tail of the net ahead of the 64 mesh extension. This resulted in a poor transition from the net to the TED extension (Figure 3A). This caused pocketing and billowing ahead of the TED. The installation location negatively affected the flap causing it to seal just a few inches down the TED frame (Figure 3B). It was apparent after this dive that a larger TED or a short straight extension was needed ahead of the TED to achieve a proper configuration. The bullet used to spread the trawl was also examined on this dive. The bullet was lying on its side when towed, which divers attributed to the net attachment point at center of the aft portion of the bullet (Figure 3C). Attaching the net to a point on the corner of the bullet should allow the bullet to ride upright.

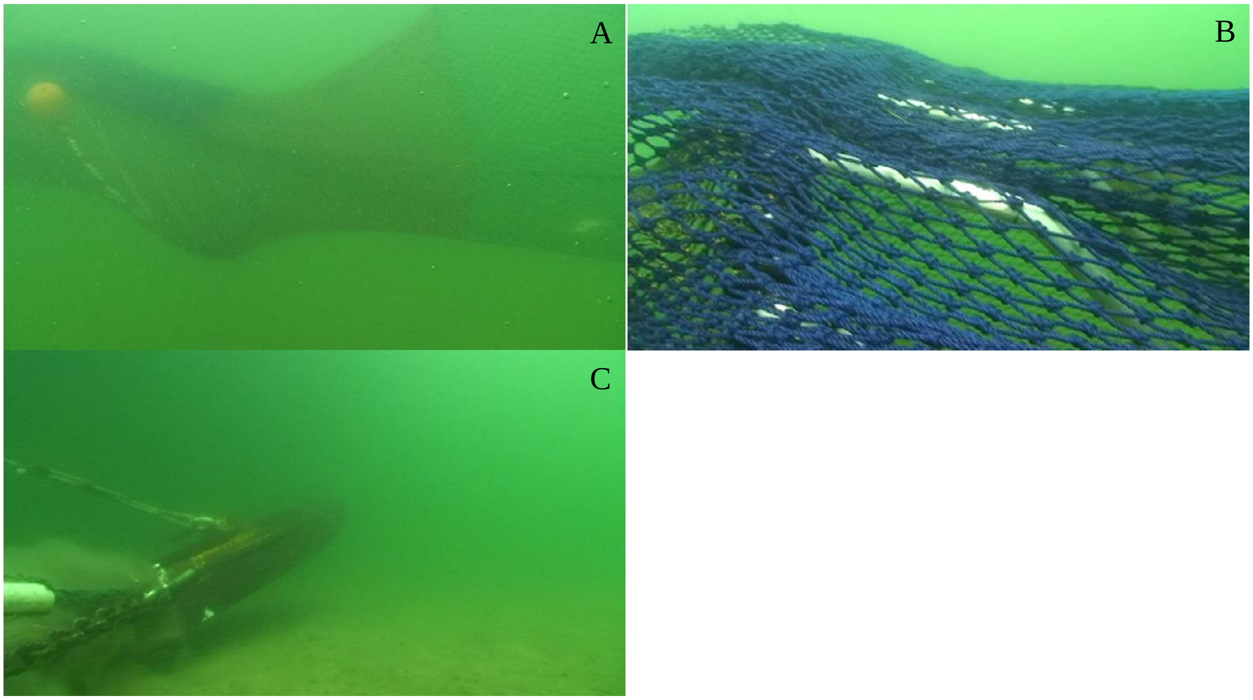

Figure 3. Photo grabs from video collected during 2012 "Kickout" frame skimmer trawl TED evaluations of a mid-size, super shooter installed in a top-opening configuration with double cover flap. A 64 mesh straight extension was installed behind the TED. A – transition between net and TED; B – flap seal; C – bullet lying down during the tow.

The third dive was conducted with a large, super shooter style TED installed in a top-opening configuration with a double cover flap. A single Spongex float was added behind the TED inside the extension. Again, the TED was sewn directly to the tail of the net ahead of the 64 mesh extension. This resulted in a poor transition from the net to the TED extension (Figure 4A). This caused pocketing and billowing ahead of the TED. Unlike the mid-sized TED, the flap seal of the large TED was good, extending to the bent portion of the deflector bars (Figure 4B). To examine the effect of floatation on flap seal, the Spongex float was removed from the TED extension. The result was a poor seal with the flap riding just above the frame (Figure 4C).

After examining footage from each of the previous dives, the 64 mesh extension was cut in half and sewn to either end of the large TED extension. The float was reinstalled and the TED and added extensions were installed between the tail of the net and the codend for the next dive. The short extension was added in an effort to improve TED configuration and maintain flap seal. The theory was that the large TED and short extension combination would cause the transition ahead of the TED to open allowing for better flow through the net.

The fourth dive was conducted with the same configuration. Divers reported that the transition between the trawl and TED was good with a large circular extension ahead of the TED where the TED was sewn to the (Figure 5A). The flap seal was good extending half way down the length of the bent bar portion of the deflector bars (Figure 5B). The Spongex float was removed to examine the effect of flotation on the flap seal. When the float was removed the TED dropped and the flap opened about 5 cm (2 in) above the TED frame.

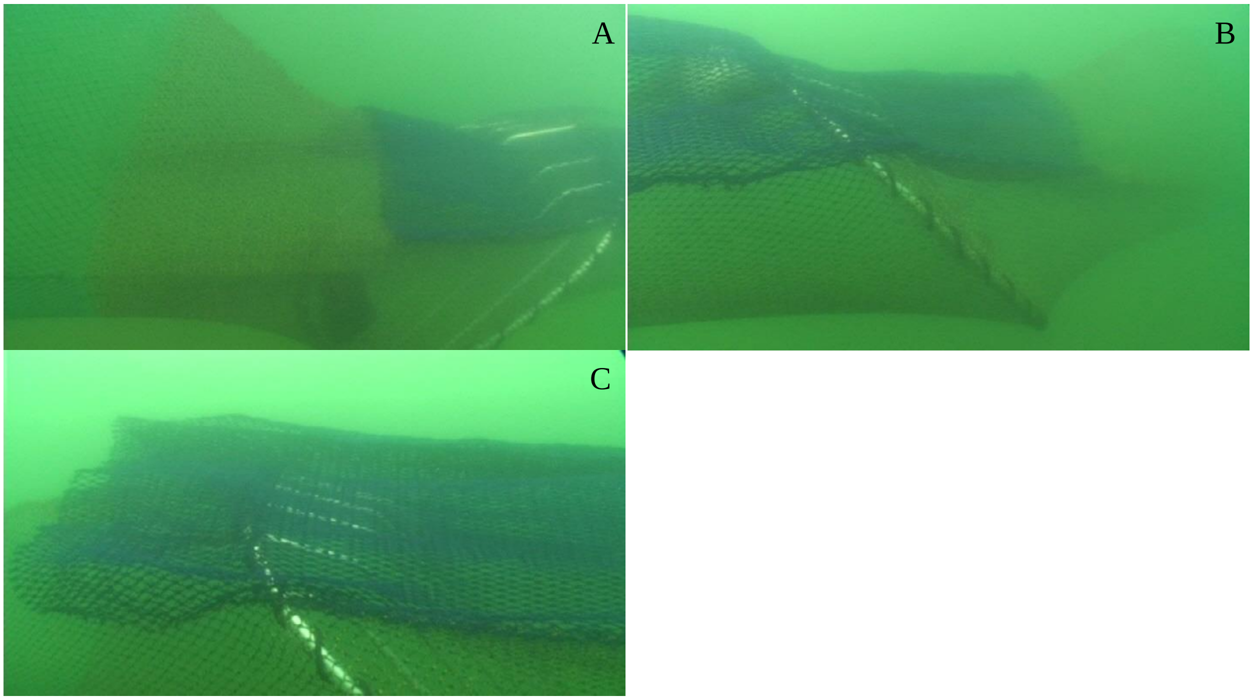

Figure 4. Photo grabs from video collected during 2012 “Kickout” frame skimmer trawl TED evaluations of a large, super shooter installed in a top-opening configuration with double cover flap. A 64 mesh straight extension was installed behind the TED. A – transition between net and TED; B – TED flap seal with floatation; C – flap seal without floatation.

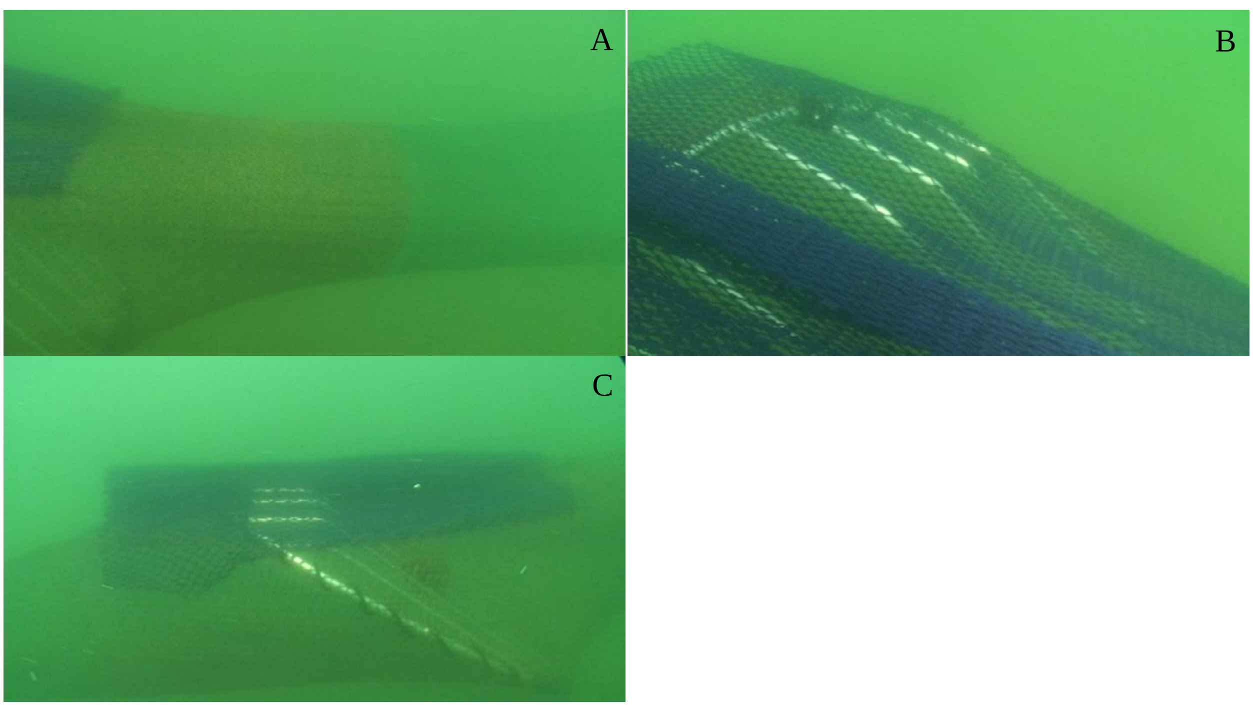

Figure 5. Photo grabs from video collected during 2012 “Kickout” frame skimmer trawl TED evaluations of a large, super shooter installed in a top-opening configuration with double cover flap. A 32 mesh long straight extension was installed ahead and behind the TED. A – transition between net and TED; B – TED flap seal with floatation; C – flap seal without floatation.

The final dive was conducted with the same configuration as the previous dive except that the TED was installed in a bottom-opening configuration. Two Spongex floats were added to the top of the TED outside of the extension. The 32 mesh extensions were added both ahead and behind the TED. Again the transition between the TED extension and trawl was good resulting in a large open circle where the TED was sewn to the 32 mesh extension (Figure 6A). The flap also looked good, sealing down the face of the grid to the bend in the deflector bars (Figure 6B). Notably, at the end of the dive a crab pot was caught, which ended up stuck at the point where the TED was sewn to the 32 mesh extension (Figure 6C). This allowed for easy removal once the TED was brought on board the vessel. The crab pot would not have made it as far down the net with the mid-size TED installed with the 64 mesh extension ahead of the TED and would have required considerable effort to remove.

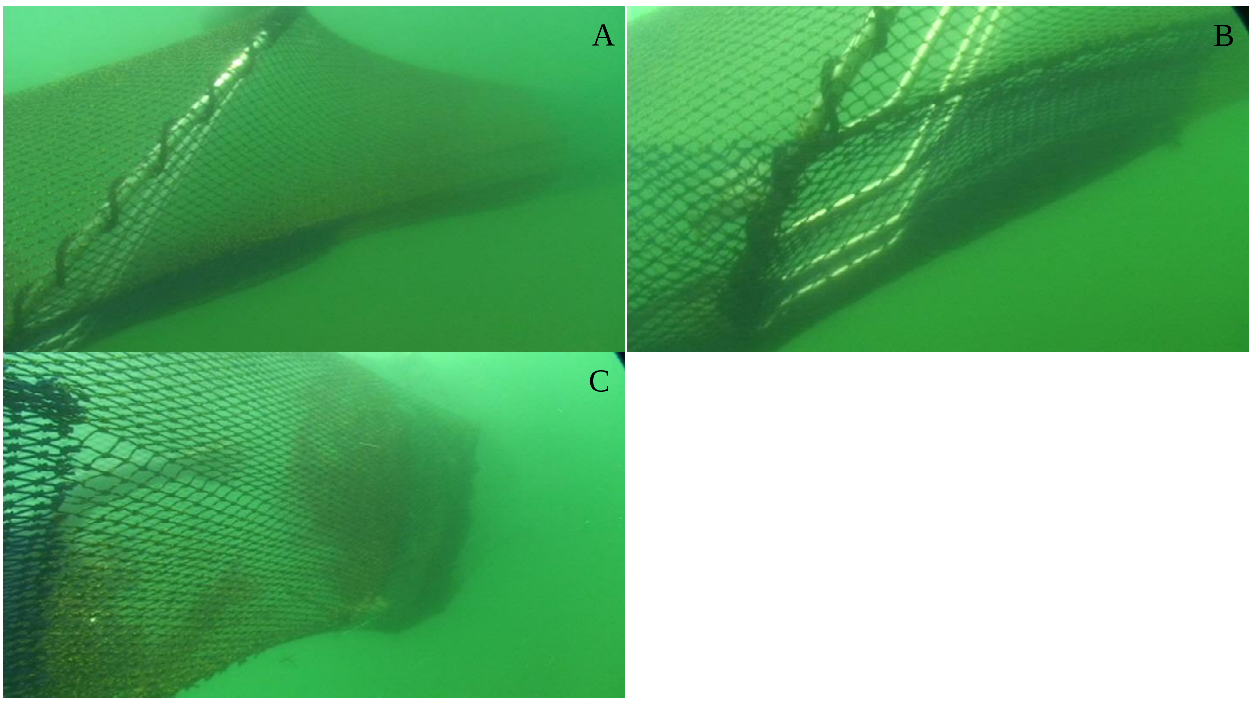

Figure 6. Photo grabs from video collected during 2012 "Kickout" frame skimmer trawl TED evaluations. The TED evaluated was a large, super shooter installed in a bottom-opening configuration with a double cover flap. A 32 mesh long straight extension was installed ahead and behind the TED. A – transition between net and TED; B – flap seal; C – crab pot captured.

Considering these results, large TEDs are recommended for these large (~7.6 m, 25 ft) skimmer trawls typically used on "Kickout" frames. Although mid-size TEDs may also be a viable option, large TEDs open the extension section of the trawl more allowing catch to move easily toward the rear of the trawl. In addition, the TED should be installed behind the last taper of the trawl and behind a short extension approximately 30 meshes long with a circumference that matches the TED extension. This improves the transition from the taper and improves flap seal. Finally, floatation should be used on top-opening TEDs to improve flap seal and assist with upright TED deployment to prevent TED twisting.

L-Shaped Frame

The first dive conducted on the "L-shaped" frame skimmer trawl evaluated a small 83.8 cm (33 in) by 83.8 cm (33 in) "Tombstone" TED with straight bars installed in a top-opening configuration with double cover flap. Two small Spongex floats were added to each side of the TED. The TED was sewn directly to the tail of the net with no extra extension added.

Upon inspection, divers discovered that the TED was installed incorrectly. However, divers were still able to evaluate the TED even though it was rolled approximately 45° to the starboard side. The area of the net ahead of the TED where the TED was sewn to the trawl had a small vertically compressed oval shape (Figure 7A). This caused the flap to seal tightly making contact approximately 30.5 cm (12 in) down the face of the grid (Figure 7B).

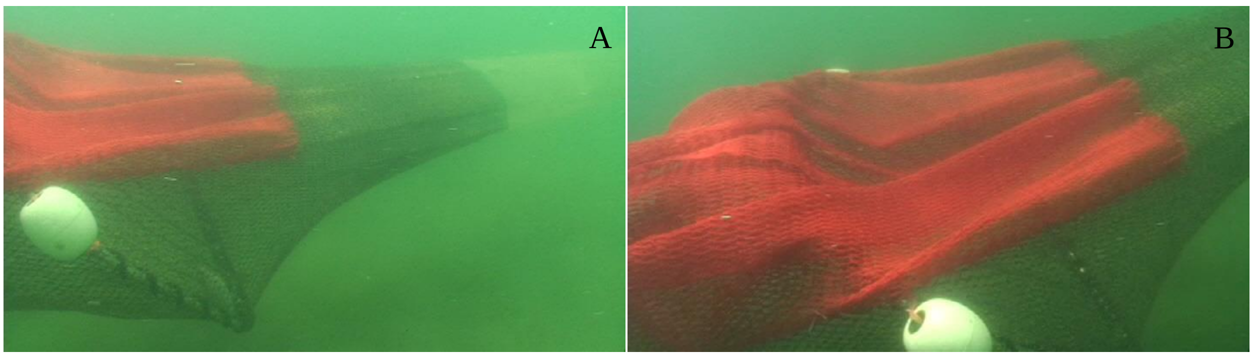

Figure 7. Photo grabs from video collected during 2012 "L-shaped" frame skimmer trawl TED evaluations of a small "Tombstone" TED installed in a top-opening configuration with a double cover flap. A – transition between net and TED; B – flap seal.

To inspect the footrope of the trawl to determine the degree of bottom contact, the TED was removed and the trawl redeployed. Divers found the bullet riding in an upright position pulling straight (Figure 8A). The footrope was still approximately 30.5 cm (12 in) off the sea floor (Figure 8B). After discussions with the captain and review of the video, the trawls were inspected and found to be improperly constructed, which was causing the footrope to lose contact with the bottom.

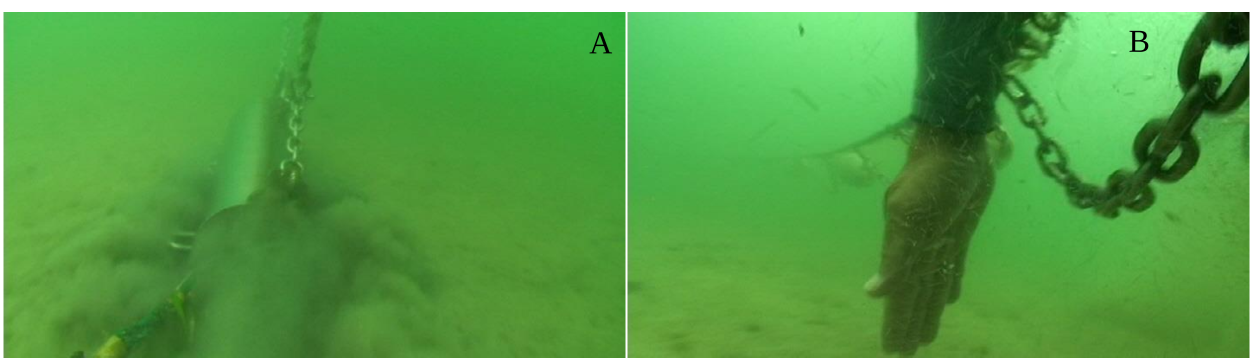

Figure 8. Photo grabs from video collected during 2012 "L-shaped" frame skimmer trawl TED evaluations with no TED installed. A – bullet configuration; B – height of footrope off the bottom.

Because the trawls were constructed poorly, only one more dive was conducted on the vessel with “L-shaped” frames. The same “Tombstone” TED used for the first dive was reinstalled correctly in a top-opening configuration. The area of the trawl where the TED was sewn to the tail of the net had a small oval shape (Figure 9A). The TED configuration looked good with a smooth transition from the trawl to the TED (Figure 9B). The small constriction ahead of the TED where it was sewn to the trawl caused the flap to seal tightly, making contact approximately 25.4 cm (10 in) down the face of the grid (Figure 9C). The TED stayed approximately 45.7 cm (18 in) off the bottom during the entire tow (Figure 9D).

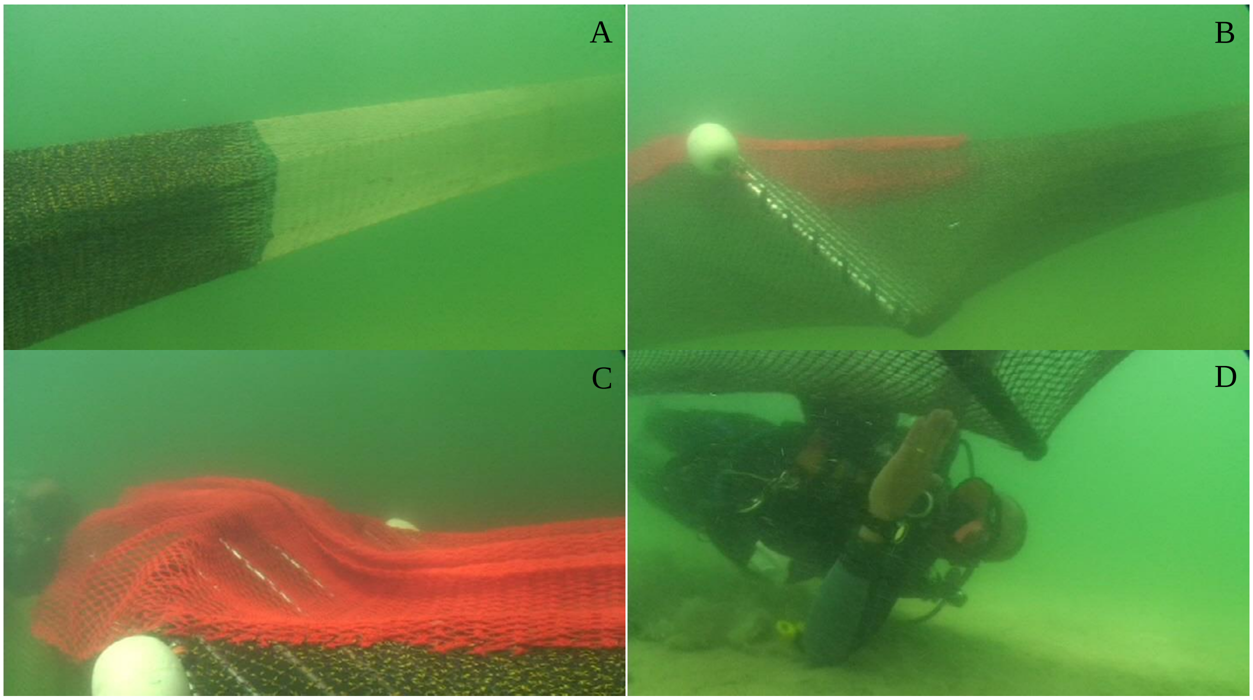

Figure 9. Photo grabs from video collected during 2012 “L-shaped” frame skimmer trawl TED evaluations of a “Tombstone” TED installed in a top-opening configuration with double cover flap. A – transition between net and TED; B – TED profile; C – flap seal; D – TED height off the bottom.

It was disappointing that the trawls provided for this portion of the work were constructed improperly. More dives need to be conducted on trawls of similar size to verify these results. However, these trials confirmed that TEDs installed in skimmer trawls are very similar to TEDs installed in otter trawls with the same factors affecting their configuration and performance. In skimmer trawls, TEDs need to be installed at a point in the trawl that prevents the trawl from collapsing down to a small diameter ahead of the TED. When this happens, there is a bottleneck ahead of the TED that could affect TED performance. Installations should be moved forward from the terminal end of the trawl ahead into the taper of the net to a point with at least a 140 mesh circumference. In addition, a short straight extension (30 meshes long) with the same circumference as the TED should be added to provide a smooth transition from trawl to TED. Larger TEDs were found to improve trawl and TED configuration by opening the diameter of the trawl ahead of the TED. Finally, flotation should be used on top-opening TEDs to improve TED flap seal.

PHASE 2 – CABLE TED EVALUATIONS

Background

Mid-Atlantic fish trawls encounter endangered sea turtles and may soon be required to use TEDs (Murray 2006). Implementing TEDs into this fishery is challenging since these fisheries typically use large nets deployed from net reels. The reels pose a significant bending problem for standard rigid frame TED grids. Because of this, the idea of a TED made from flexible material that is readily available such as cable seemed to be a plausible solution. However, the construction of a TED composed entirely of cable is challenging. Not only is there a considerable amount of labor required, but devising a good configuration is complex. The design must allow sea turtles to escape and also minimize target catch loss.

To meet this challenge, Harvesting System's Fisheries Methods and Equipment Specialist (FMES), Nick Hopkins, designed and developed the Cable TED (CTED). The CTED has been trialed in the commercial industry for several years with positive results. The CTED has proven to be effective in the croaker fishery with regard to catch retention, bycatch reduction, durability, and ease of use. Industry feedback confirms these results with one fisherman using the device voluntarily during periods of high bycatch.

In addition to commercial trials, extensive diver evaluations have been conducted on the CTED over the past several years (Hataway and Gearhart 2010, 2011, 2012).

Project Objectives

- Diver evaluations and video collection of several CTED prototypes in both flynet and flounder trawls
- Measure CTED deflector bar flexibility when towed
- Document and improve flap sea configuration of the CTED
- Examine the CTED in a bottom-opening configuration

Methods

During this phase of testing, the CTED was evaluated in fish trawls, therefore a stern trawl vessel capable of deploying large nets from a net reel was needed. A 19.8 m (65 ft) steel hull, stern trawler, *F/V Capt. Wick*, owned and operated by Bosarge Boats Inc. from Pascagoula, Mississippi was chartered for this portion of the study. The vessel was utilized to tow fish trawls used in both the Mid-Atlantic flynet and flounder trawl fisheries. The trawls employed for this phase of the project were a 29.5 m (85 ft) flynet trawl, a 17.1 m (56 ft) four-seam flounder trawl, and a 17.1 m (56 ft) two-seam flounder trawl. Each net was deployed from the vessels net reel and spread by 3.5 m^2 (37.7 ft^2) steel "V" doors and towed at either 2.5 or 3.0 kts. Operations were conducted approximately 0.4 km (0.25 mi) offshore of Shell Island, adjacent to Panama City Beach, Florida in depths from 6.1 m (20 ft) to 9.1 m (30 ft) (Figure 1).

To achieve the objectives of the study, several dives were conducted to determine optimum TED position, amount of floatation, and location of floats. The first concern was the overall shape of the CTED, while the next concern was the closure of the webbing flap over the escape opening. The flap must seal tight enough to deter the target catch from escaping, while still remaining loose enough to allow turtles to easily escape.

Results

Improving Configuration and Flap Seal

Eight dives were conducted to adjust floatation in an attempt to improve the shape of the CTED, while maintaining a good flap seal. The first dive was made with the maximum number of 20.3 cm (8 in) floats. There were four along each gore, six along the middle deflector bar and 12 along the Back Strap (BS) around the edge of the escape opening (Figure 10). There were a total of 26 floats added measuring 20.3 cm (8 in) and providing 3.2 kg (7 lb) of floatation each. Total buoyancy added was 82.6 kg (182 lb) with the stainless steel cable weighing approximately 79.4 kg (175 lb). Considering that all other materials were neutrally buoyant, the flap would not seal even with this maximum amount of floatation added to the grid. The flap was open about 45.7 cm (18 in) above the BS, which was a good indicator that the frame was elongated from the top to bottom. This is not the best configuration for target retention. The height of the Lead Ring (LR) averaged about 2.3 m (7.5 ft), which was well beyond the 1.8 m (6 ft) mark that would indicate that the LR was a symmetrical circle. The shape of the grid affects bar spacing. When the frame is round the grid bar spacing is at its widest, allowing target catch to pass through the grid easily. When the frame is oblong (sides come together) the bar spacing is narrower and target catch may be excluded.

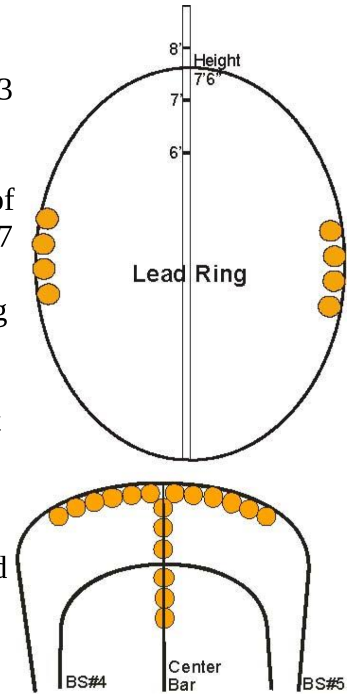

Figure 10. Location of floats and height measuremts on CTED.

Observations from 2011 testing using this same CTED found that the flap sealed well with 73.5 kg (162 lb) of floatation. This demonstrated the influence that the net has on the CTED's shape when towed. The 2011 observations were conducted with a 19.8 m (65 ft) sampling trawl, while this year's observations employed a 29.5 m (85 ft) flynet. Since the tail of the net was oval, a 50 mesh extension was installed between the body of the net and the CTED. The mesh size and circumference of the added extension matched that of the CTED extension and prevented the net from influencing the shape of the CTED. In addition, the extension helped to relax the webbing on the top of the CTED. However, this did not improve the flap seal. Divers observed the stiff arch on the top of the LR causing the attached flap to stay from 30.5 cm (12 in) to 45.7 cm (18 in) above the opening. Nevertheless, divers did observe the bottom of the grid remaining parallel with the bottom of the net, which indicated that the proper amount of floatation was used.

The arch of cable on the LR of the CTED should be corrected to allow the flap to seal over the escape opening. The floatation on the gores may have contributed to pushing the arch of the cable up. Therefore the positioning of the floats was changed. Four floats were added to the bottom of the LR and two floats were removed from each side of the gores. With this float arrangement, the flap was still not sealed. However, the floatation arrangement changed the shape of the CTED from oval to a flat bottom egg-shape.

Bar Spacing

Bar spacing in all TEDs should be 10.2 cm (4 in) or less. Inside the CTED, measurements were taken using a metal wedge to force apart the cables that make up the grid (Figure 11). The graduated wedge was placed between the bars (cables) in the most flexible area located in the middle section of the grid. Next, the wedge was pushed further down between the bars with 9.1 kg (20 lb) of force applied to determine how much further the bars could spread. Unfortunately the deflector cables are attached to the outer frame with flexible couplers that allowed just enough bend for the bar spacing to exceed 10.2 cm (4 in) (Table 1).

Figure 11. Graduated metal wedge used to allow divers to measure CTED bar spacing.

Table 1. Bar Spacing measurements in selected areas of the CTED using a graduated wedge with and without 9.1 kg (20 lb) of pressure.

		Spread (cm)		
Area	**Pressure (kg)**	**Center**	**Quarter**	**Edge**
Top Row	0.0	7.6	7.6	7.6
Top Row	9.1	11.4	11.4	11.4
Middle Row	0.0	7.6	7.6	7.6
Middle Row	9.1	7.6	7.6	7.6

Bottom-opening CTED

The next three dives looked at a CTED in the bottom-opening configuration. The first dive had the 50 mesh extension attached and the TED was loaded with floatation. Subsequent dives trimmed floats as needed. For the first dive, four floats were sewn to either side of the center bar at the top of the LR. There were also four floats on both gores and four floats on either side of the center bar on the BS and three floats on the center bar. Dive observations showed the LR to be round but the flap still had a gap of over 45.7 cm (18 in). During dive five, the floats on the top of the LR were cut off decreasing the LR height from 2.1 m (7 ft) to 2.0 m (6.7 ft) with the gap between the flap and opening decreasing to 30.5 cm (12 in). On dive six, two floats were added to the bottom of the LR to help seal the flap, which caused the lead ring to arch up and cause the flap to go up inside the grid face causing the seal to be excessive. These dives showed that it was advantageous to have the section of the LR ahead of the flap (top or bottom-opening) to be flat, which gives the best seal for the escape flap. Floatation added to the leading edge of the grid should be distributed towards the corners around six bars from the center of the grid.

Top Shooting CTED with Nylon Line on the Lead Ring

Returning the CTED back into a top shooting position, two dives were conducted. The first dive focused on the arch of the webbing at the top of the LR. The stiff 14.3 mm (9/16 in) cable was removed and replaced by 9.5 mm (3/8 in) nylon line. The flexible line made it easier to pack the CTED on the reel and also to apply ballast to allow the flap seal better. Diver observation found the rope section of the LR to be effective at reducing the arching and leveling the top of the CTED. When additional ballast of 3.6 kg (8 lb) was added, the flap went from 20.3 cm (8 in) above the back strap down to being flush. This additional ballast was accomplished by adding a length of 9.5 mm (3/8 in) chain to the nylon. This additional ballast made the flap have light contact with the opening. It appeared that a flatter LR would likely make the flap seal better.

Conclusions

Lead Ring

- The shape of the LR determines the shape of the flap. The flatter the LR in front of the flap the tighter the flap seal.
- The LR in front of the opening has to be the same height as the BS for the flap to make contact.
- Compressing the LR top to bottom results in the best flap contact. This is achieved through the use of ballast chain on the top-opening orientation and floats on the bottom-opening orientation.
- Adding floatation on the side/gores prevents the LR from vertically compressing and results in poor flap seal.
- The gore floats pushed up the LR, arching the cable for an oval LR shape and poor flap seal.
- Top-opening orientation looks better with chain instead of cable on the LR ahead of the opening.
- Cable helps hold the LR's shape and locks into the meshes on both top and bottom-opening orientations.

Bar Spacing

- The terminal connector ends of the grid have variable bar spacing.
- The bar spacing at the center of the grid is locked into place well.
- An additional cable needs to be installed parallel to the terminal ends of the grid to control movement of the terminal coupler.
- To reduce bar spacing variability, the CTED needs the cable layout to be reconfigured to shorten the terminal ends of the grid bar cables.

Top-opening CTED

The best configuration has the LR at the top between the BS replaced with 9.5 mm (3/8 in) chain, eight floats across the bottom of the grid, and three floats at the top middle bar. The 50 mesh extension added ahead of the CTED improves the shape of the grid. To investigate this, additional dives are needed on the CTED with chain installed across the top of the LR, without gore floats, and eight floats installed across the bottom of the grid. An additional dive with the new LR modifications and 16 floats installed along the middle bar may also be helpful. To achieve proper floatation, there should be between 21 and 25 floats installed on the grid.

Bottom-opening CTED

The weight of the grid provides a good shape in a bottom-opening orientation. However, the grid benefits from some floatation installed at the top of the grid in the corners. This allowed the center of the grid to fall some and square off, providing the maximum bar spacing. The bottom of the LR at the leading edge of the CTED needs some floatation to keep it level or above the grid opening, which provides a good flap seal. Floats should not be installed along the center of the grid and should instead be installed equidistant from and no more than one foot from the center so they fall in line with the inside quarter of the flap. This should be examined with and without the addition of the 50 mesh extension ahead of the grid.

PHASE 3 – SMALL TURTLE TED TESTING

Background

All five species of sea turtle that occur in continental U.S. waters are protected under the Endangered Species Act of 1973 (ESA PL93-205). Subsequent to passage of the ESA, shrimp trawls were identified as a significant source of sea turtle mortality (National Research Council 1990). In response, research was initiated to develop TEDs for the shrimp trawl fishery in an effort to provide a safe method for turtles to escape.

A TED is a grid installed in the aft portion of a trawl net, which has an opening in the bottom or top of trawl to provide captured turtles an avenue for escape. When turtles and other large animals are caught, they bump into the grid and slide through the opening, while shrimp and other small organisms pass through the grid and end up in the cod end of the trawl.

Since the TED was first introduced to the U.S. shrimp fishery in the late 1980's, research and development to improve TED performance has continued. A direct result of this research was the development of a process to evaluate TED performance. The process used by NMFS to evaluate TED's changed significantly over the first 15 years of research. Initially, TEDs were tested through paired comparisons aboard a vessel rigged to tow two nets. A TED was installed in one trawl, while the other was towed "naked" without a TED. This protocol was consistently used through 1985 and provided for the evaluation of TED shrimp retention under various fishing conditions. However, the protocol was not well suited to evaluate sea turtle exclusion. In 1986, the Cape Canaveral testing protocol was developed during which a naked net (control) was towed against a net with a candidate TED in an area with high concentrations of sea turtles. This protocol compared the number of wild turtles caught in a trawl with a TED installed with the number caught in a control net without a TED. The Cape Canaveral ship channel was known to have a very high density of sea turtles, so testing in this area almost insured that both control and experimental TED nets would encounter sea turtles. From 1986 to 1989, NMFS evaluated industry-developed TED's utilizing this protocol to certify them for commercial use (Federal Register, Vol. 52, No. 124). The test was eventually abandoned in 1989, due to scarcity of turtles in the study area. In 1988, NMFS began to develop a new protocol that utilized captive-reared sea turtles. This procedure evolved into the small turtle TED testing protocol that is used today (Federal Register, Vol. 55, No. 195).

For 2012 testing, the small turtle protocol was utilized to test variations of different TED components and installation configuration to evaluate the effect each may have on sea turtle exclusion. These variations included TED angle, TED orientation, curvature of grid bars, and amount of overlap on double-cover flaps. This portion of the project was performed aboard the NOAA/NMFS vessel *R/V Caretta*, a 19.8 m (65 ft) twin rigged shrimp trawler.

Project Objectives

- Conduct a full turtle test (25 turtles) of a bottom-opening control TED; a mid-sized, curved bar TED with a double cover flap.
- Conduct a full turtle test (25 turtles) of a top-opening control TED; a mid-sized, curved bar TED with a double cover flap.
- Conduct a full turtle test (25 turtles) of a bottom-opening, mid-sized, curved bar TED installed at 71° with a double cover flap.
- Conduct a partial turtle test (10 turtles) of a top-opening Costa Rican TED with 15.2 cm (6 in) bar spacing and double cover flap, to determine if turtles have greater difficulty escaping TEDs with larger bar spacing.
- Conduct a full turtle test (25 turtles) of a top-opening TED with straight bars installed at 51° with a double cover flap with 50.8 cm (20 in) of overlap (when stretched).
- Conduct a partial turtle test (10 turtles) of a bottom-opening TED with straight bars installed at 71° with a 108.3 cm (71 in) single cover opening.

Methods

Turtles

For these tests, 163 two year-old (2010 year class) and 37 three year-old (2009 year class) loggerhead sea turtles (*Caretta caretta*), were obtained from the NMFS, SEFSC, Galveston Laboratory sea turtle facility. Acclimation and conditioning of the turtles was conducted in turtle pens located at the NMFS, SEFSC, Panama City, FL Laboratory for a four week period prior to testing (Figure 1). Divers attempted to recapture all turtles after exposure to candidate TEDs. Turtles were returned to containment pens at the end of each day.

TED Testing

All TED designs and modifications were tested according to the small turtle testing protocol. For each test, samples of turtles were exposed to a candidate TED equipped trawl under normal towing conditions. Turtles were transferred from the deck of the research vessel to divers on the trawl via a 3.2 mm (1/8 in) stainless steel messenger wire attached at the stern of the vessel and connected to the trawl headrope. Turtles were placed inside a 63.5 cm (25 in) x 63.5 cm (25 in) mesh bag at the surface, attached to the messenger wire with a snap clip, and sent underwater to divers riding on the trawl. Transit time for the turtle from the surface to the trawl was approximately one minute. Turtles were released from three different positions along the trawl headrope to mitigate bias which might be associated with release position (Figure 12). Release positions on the trawl headrope were determined by dividing the headrope into three equal length sections and using the center points of each section as the release position. This method resulted in a center headrope release point and two wing release points. The release position for each turtle was determined through random selection prior to initiating the test of a candidate TED (Table 2). At the completion of eight random sequences, the order was repeated.

Three scuba divers monitored each test. Diver #1 released the turtle into the trawl and took a position behind the TED to assist with turtle recapture. Diver #2 monitored the turtle's passage through the net, recaptured the turtle, and recorded escape time data. Diver #3 videotaped each test using an underwater video camera. Upon release at the headrope, a stopwatch was started and each turtle was allowed 5 min to escape through the TED. At the end of 5 min, if the turtle was still within the trawl, it was removed by a diver. If a turtle was determined to be overly stressed during the 5 min exposure period, it was removed from the trawl, returned to the vessel immediately, and was not included in the sample. Data recorded during each exposure included; video record, total time in the trawl, turtle activity level, and turtle disposition (escape or capture). An individual turtle's activity level was subjectively scored by divers in one of the following categories; very active (A), moderately active (B), and no or little activity (C).

Figure 12. Turtle release position for 2012 small turtle testing.

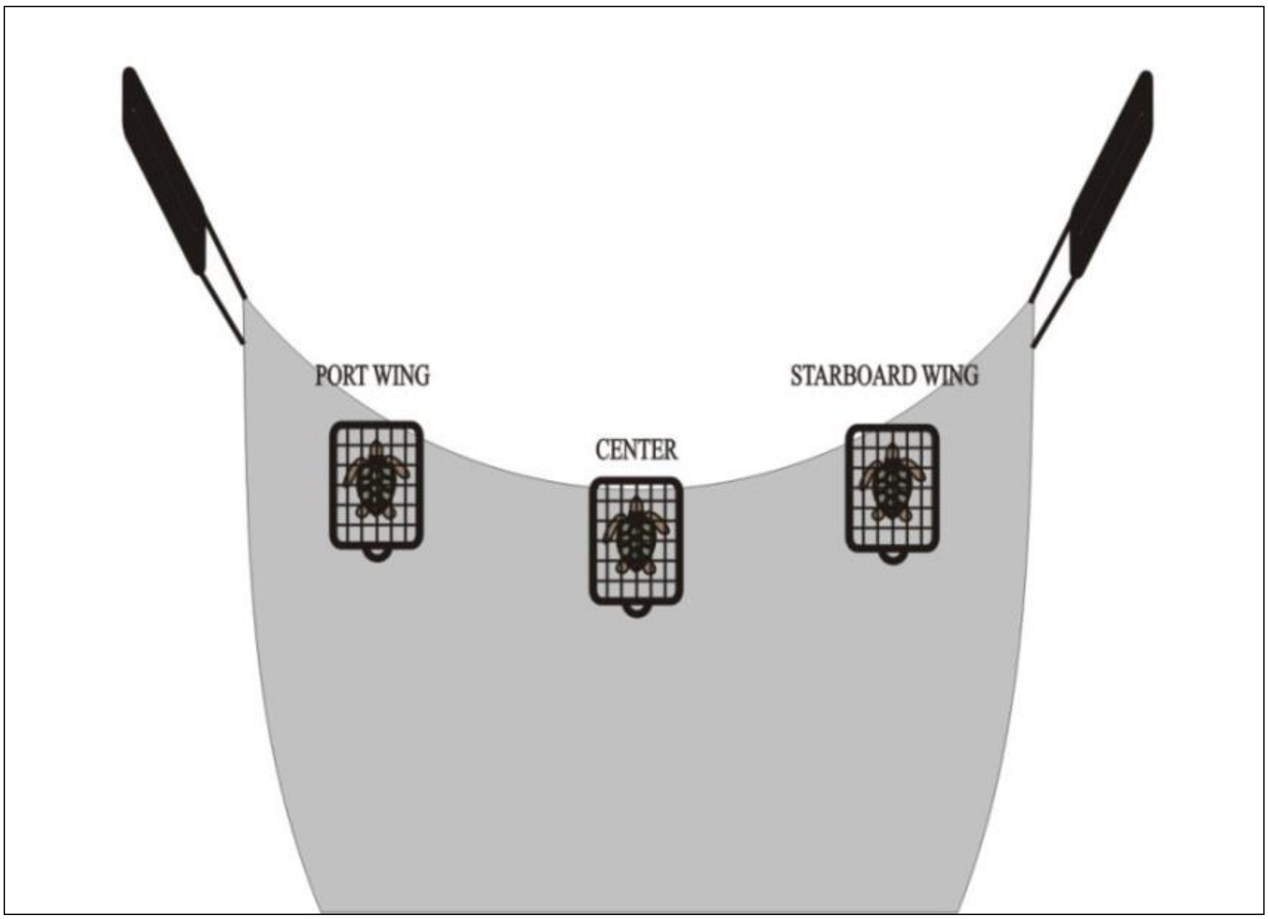

Table 2. Random turtle release sequence on the trawl headrope for 2012 TED testing.

Sequence	Sequential order of release		
	Order 1	Order 2	Order 3
1	C(4) P(4) S(4)	P(4) S(4) C(4)	S(1)
2	P(4) C(4) S(4)	P(4) S(4) C(4)	C(1)
3	P(4) C(4) S(4)	S(4) C(4) P(4)	S(1)
4	C(4) P(4) S(4)	C(4) P(4) S(4)	C(1)
5	S(4) P(4) C(4)	C(4) P(4) S(4)	C(1)
6	C(4) P(4) S(4)	P(4) S(4) C(4)	C(1)
7	C(4) P(4) S(4)	S(4) P(4) C(4)	C(1)
8	S(4) C(4) P(4)	C(4) S(4) P(4)	S(1)

P = Port (wing) position; C = Center position; S = Starboard (wing) position
(x) = no. of turtles released

Statistical Protocol

The relative efficiency of each candidate TED design was compared to that of a control TED tested under the same conditions with the same year class of turtles. A standard mid-sized, top-opening, bent-bar TED (Super Shooter $_{TM}$) with a double cover flap configuration was used as a control TED. The double cover TED opening was developed by NOAA Fisheries in 1999 as an alternate method of obtaining an opening large enough to exclude leatherbacks and other large sea turtles. The standard mid-sized control TED was installed at an angle of 50º. A 25 turtle exposure test was conducted using the control TED to establish a baseline used to evaluate candidate TEDs. The statistical procedures used to evaluate candidate TEDs are:

1. The control TED was tested in a top-opening configuration using a sample of 25 turtles.

2. Null Hypothesis (Ho) = exclusion rate of the candidate TED is greater than or equal to that of the control TED.

3. Alternate hypothesis (Ha) = exclusion rate of the candidate TED is less than that of the control TED.

4. The number of turtle captures required to reject a candidate TED (decision rule) using a sample of 25 turtles is derived through assessment of the probabilities of committing Type I and Type II error. These errors are defined as:

    a. **Type I Error (α)**: Rejection of a candidate TED which is as good as or better than the control TED (Risk of rejecting an acceptable TED)
    b. **Type II Error (ß):** Acceptance of a candidate TED which is inferior to the control TED (Risk of accepting an unacceptable TED)

Results

Turtles

Not all turtles obtained for testing were used. One hundred and forty eight (148) of the 163 two year-old loggerheads were used for TED testing, while six of the 37 three year old turtles were used.

The two year-old turtles used had a mean straight line carapace length (SCL) of 34.0 cm with a range of 30.9 - 36.1cm SCL. Mean carapace width was 27.3 cm straight carapace width (SCW), and mean weight was 5.5 kg (12 lb). The mean body depth (BD) of the two year-olds was 14.3 cm with a range of 13.0-15.5 cm. The three year-old turtles used had a mean length of 43.3 cm SCL with a range of 41.2- 46.0 cm SCL. Mean width was 34.8 cm SCW and mean BD was 17.8 cm, which ranged from 17.2 to18.5 cm. The mean weight of the three year-old turtles was 10.8 kg (23.9 lb).

Two of the two year-old and one of the three year-old turtles were lost during testing. After TED testing was completed, 132 two year-old turtles were released into the Gulf Stream near Ft. Pierce, Florida, while the remaining 36 three year-old turtles were released at Sebastian Inlet State Park. A total of 31 two year-old turtles were returned to the Sea Turtle Facility at the NMFS Galveston, TX Laboratory for research.

Control TEDs

The bottom-opening control TED was the first TED tested. The control TED was a mid-sized, 104 cm (41 in) x 81.3 cm (32 in), oval, bent-bar design installed at 51^{o} (49.9^{o} hanging). The TED escape opening cut was rectangular and was 54.6 cm (21.5 in) long by 147.3 cm (58 in) wide (15 meshes by 45 meshes) and had a double cover flap constructed of 41.3 mm (1 5/8 in) mesh heat set, depth stretched polypropylene webbing. The flap was made from two pieces of webbing 60 meshes wide by 33 meshes long. The flaps overlapped each other by 35.6 cm (14 in) (when stretched) along the center of the opening. The overhang was 61 cm (24 in) beyond the posterior edge of the grid. This TED had 15.9 mm (5/8 in) aluminum rod bars spaced 8.9 cm (3.5 in) apart. The TED was equipped with one 22.9 cm (9 in) by 12.7 cm (5 in) Spongex float attached to the top center of the grid on the outside of the webbing. The TED was installed in a sapphire webbing extension 60 meshes long and 150 meshes in circumference.

The initial test of the bottom-opening control scored seven captures out of 25 turtles tested with a median escape time of 145 s (2 min 25 s, Table 3). The activity level of the turtles tested appeared off to divers and results were compared to the performance of identical bottom-opening control TEDs from four previous tests (2006, 2007, 2008, and 2011). Previous testing showed capture rates no greater than one turtle in each sample of 25. Because of the major discrepancy in performance when compared to previous tests, an additional test of the bottom-opening control was conducted on June 15th and 17th. The second test resulted in all 25 turtles escaping successfully (Table 3). The median escape time was 102 seconds (1 min 42 sec) with a range from 23-287 seconds (Table 3).

Table 3. Bottom-opening control TED gear characteristics and results of small turtle testing.

Gear Characteristics	Description	Comments	Test Score	Escape Time
TED Type	Control; mid-size, bent bar, rod; 104 cm (41 in) H x 81.3 cm (32 in) W	Good configuration; Retested due to high capture rate	**Test 1** 7 captures 18 escapes **Test 2** 0 captures 25 escapes	Mean = 106.4 s Median = 145 s Range = 16-235 s Mean = 118.6 s Median = 102 s Range = 23-287 s
Orientation	Bottom-opening			
Net type	Western Jib 15.2 m (50 ft)			
Door type/size	Wooden; 2.4 m (8 ft) x 101.6 cm (40 in)			
Installer	NMFS			
Floatation	1 Spongex top center; 22.9 cm (9 in) x 12.7 cm (5 in)			
Opening	54.6 cm (21.5 in) L x 147.3 cm (58 in) W			
Flap	41.3 mm (1 5/8 in) poly, double cover; 35.6 cm (14 in) overlap; 61 cm (24 in) overhang			
Angle	51°			

The top-opening control was tested next. This was the same TED used for the bottom-opening control test installed in a top-opening orientation with the float removed. This TED excluded all 25 turtles with zero captures. The median escape time was 63 s (1 min 3 s) and ranged from 13 to 180 s (Table 4).

Table 4. Top-opening control TED gear characteristics and results of small turtle testing.

Gear Characteristics	Description	Comments	Test Score	Escape Time
TED Type	Control; mid-size, bent bar, rod; 104 cm (41 in) H x 81.3 cm (32 in) W	Good configuration	0 captures 25 escapes	Mean = 116.4 s Median = 106 s Range = 13-180 s
Orientation	Top-opening			
Net type	Western Jib 15.2 m (50 ft)			
Door type/size	Wooden; 2.4 m (8 ft) x 101.6 cm (40 in)			
Installer	NMFS			
Floatation	None			
Opening	54.6 cm (21.5 in) L x 147.3 cm (58 in) W			
Flap	41.3 mm (1 5/8 in) poly, double cover; 35.6 cm (14 in) overlap; 61 cm (24 in) overhang			
Angle	51°			

Decision Rule

Based on the performance of the control TEDs the following pass/fail criteria were established for testing candidate TEDs. Based on the performance of the control TEDs and maintaining an α

of at least 22%, a decision rule was derived (1995 TED test review committee report). Testing of a top-opening candidate TED could be terminated after it had failed to release two turtles within the 5 min exposure period. This capture rate corresponds to an α of 0.08 and a ß of 0.27 for a TED that is 90% effective at releasing turtles. Based on the performance of the bottom-opening control TED using the same decision rule, a candidate bottom-opening TED would be terminated after it failed to release four turtles within the 5 minute exposure period.

Top-opening Bent Bar (Super Shooter) TED with a Steep Angle (71^0)

Due to high numbers of sea turtle mortalities and poor TED compliance rates during the past two years, evaluations designed to examine how TED grid angle affects sea turtle escape rates were conducted. A TED, identical to the top-opening control TED, was installed at an angle of 71^0 (Table 5).

A total of eight turtles were exposed to this TED with all turtles escaping within the 5 minute exposure period. The median escape time was 39.5 s (mean = 61 s) with a range of 21-159 s (Table 5). These results illustrate the high efficiency of this TED design in excluding turtles. Even though the TED was installed at an angle which was 16^o steeper than legally allowed, the TED performed as well as the top-opening control. This can be attributed to the design of the bent bar style grid (Super Shooter), which has the distal portion of the grid bent at a lower angle to allow bycatch and debris to be removed from the TED more easily.

Table 5. Top-opening bent bar TED installed at an angle of 71^0 gear characteristics and results of small turtle testing.

Gear Characteristics	Description	Comments	Test Score	Escape Time
TED Type	Mid-size, bent bar, rod; 104 cm (41 in) H x 81.3 cm (32 in) W	Steep Angle	0 captures 8 escapes	Mean = 61 s Range = 21-159 s
Orientation	Top-opening			
Net type	Western Jib 15.2 m (50 ft)			
Door type/size	Wooden; 2.4 m (8 ft) x 101.6 cm (40 in)			
Installer	NMFS			
Floatation	None			
Opening	50.8 cm (20 in) L x 153.7 cm (60.5 in) W			
Flap	41.3 mm (1 5/8 in) poly, double cover; tapered; 35.6 cm (14 in) overlap; 58.4 cm (23 in) overhang			
Angle	71°			

Bottom-opening Bent Bar (Super Shooter) TED with a Steep Angle (71^0)

In addition to examining steep angles in a top-opening configuration, the bent bar style TED was also evaluated as a bottom-opening TED. This evaluation was conducted with the same TED used in the top-opening configuration test. All TED dimensions were the same as in the previous test (Table 6).

During previous testing, both top and bottom-opening control TEDs have been evaluated. With regard to small turtle testing, results indicate that TEDs exclude sea turtles more efficiently when installed in a top-opening configuration. This may be attributed to possible instinctive behavior of the forcibly submerged captive-reared turtles seeking the surface when stressed. Previous small turtle testing also revealed that sea turtles require more time to find the escape opening of a bottom-opening TED when compared to an identical top-opening TED. These results may be attributed to the orientation of the captive-reared turtles when making initial contact with the grid. For top-opening TEDs, turtles typically make initial contact with their plastrons, which allows them to move along the face of the grid easily. In contrast, turtles typically make initial contact with bottom-opening grids with their carapaces, which makes movement along the face of the grid more difficult.

A sample of f 25 turtles was exposed to this TED with four captures recorded. This was recorded as a failure, when compared to the bottom-opening control. The median escape time for this TED was 89 s (mean = 103.1 s, range 30-290 s) (Table 6).

Table 6. Bottom-opening bent bar TED installed at an angle of 71^0 gear characteristics and results of small turtle testing.

Gear Characteristics	Description	Comments	Test Score	Escape Time
TED Type	Mid-size, bent bar, rod; 104 cm (41 in) H x 81.3 cm (32 in) W	Steep Angle	4 captures 21 escapes	Mean = 103.1 s Median = 89 s Range = 30-186 s
Orientation	Bottom-opening			
Net type	Western Jib 15.2 m (50 ft)			
Door type/size	Wooden; 2.4 m (8 ft) x 101.6 cm (40 in)			
Installer	NMFS			
Floatation	1 Spongex top center; 22.9 cm (9 in) x 12.7 cm (5 in)			
Opening	50.8 cm (20 in) L x 153.7 cm (60.5 in) W			
Flap	41.3 mm (1 5/8 in) poly, double cover; tapered; 35.6 cm (14 in) overlap; 58.4 cm (23 in) overhang			
Angle	71°			

<u>Costa Rican TED with 15.2 cm (6 in) Bar Spacing</u>

Costa Rica allows TEDs with a maximum bar spacing of 15.2 cm (6 in) in their shrimp fishery, which is 5.0 cm (2 in) larger than the 10.2 cm (4 in) maximum spacing allowed in the U.S. During 2011 TED testing, a bottom-opening Australian TED with 12 cm (4.7 in) bar spacing was evaluated (Hataway and Gearhart 2012). The TED performed poorly with numerous contributing factors identified. However, the most obvious was the inability of turtles to readily move along the grid. Because it was a bottom-opening TED, turtles made initial contact with their carapace and the wider bar spacing allowed the ridge of the carapace to protrude between the bars. This made it difficult for turtles to turn around and move along the face of the grid.

To further examine this problem, the Costa Rican TED was tested with three year-old loggerhead turtles. These turtles were larger than the two year-old turtles typically used during TED testing with a mean SCL of 43.3 cm SCL (range 41.2-46.0 cm). The mean body depth of these turtles was 17.8 cm BD (range 16.6-18.5 cm). The expectation was that the carapace morphology of the larger three year-old turtles would allow them to move along the grid more easily resulting in more escapes. The Costa Rican TED excluded five of six turtles exposed to it with an average escape time of 83.5 s (Table 7).

Table 7. Top-opening, Costa Rican TED with 15.2 cm (6 in) bar spacing gear characteristics and results of small turtle testing.

Gear Characteristics	Description	Comments	Test Score	Escape Time
TED Type	Costa Rican, rod; 15.2 cm (6 in) bar spacing; 129.5 cm (51 in) H x 113 cm (44.5 in) W	3 yr old turtles Mean SCL = 43.3 cm Mean BD = 17.7 cm	1 capture 5 escapes	Mean = 83.4 s Median = 76 s Range = 40-126 s
Orientation	Top-opening			
Net type	Western Jib 15.2 m (50 ft)			
Door type/size	Wooden; 2.4 m (8 ft) x 101.6 cm (40 in)			
Installer	NMFS			
Floatation	2 Spongex attached to sides; 22.9 cm (9 in) x 12.7 cm (5 in)			
Opening	66 cm (26 in) L x 193 cm (76 in) W			
Flap	41.3 mm (1 5/8 in) poly, single flap; 61 cm (24 in) overhang			
Angle	49°			

Straight Bar TED, Top-opening with Double Cover Flap and 50.8 cm (20 in) Overlap

The double cover opening is an enlarged opening designed by Harvesting Systems staff to allow larger sea turtles to escape from shrimp trawls. The opening was certified and allowed as an alternative for shrimp fishermen on February 21, 2003 (Federal Register, Vol. 68, No. 35). The opening consists of two overlapping flaps sewn side by side covering the escape opening. The flaps overlap in the center and are attached along the leading edge and down the sides along their entire length. The amount of overlap determines how large the escape opening will be and how easily the flaps will open. Federal regulations allow the two flaps to overlap by a maximum of 38.1 cm (15 in) when stretched. This amount of overlap has been found to be sufficient to keep the flap closed during fishing yet allow it to open easily to allow small sea turtles to escape.

To examine how increasing the amount of overlap effects small turtle escape rates, a TED with 50.8 cm (20 in) of overlap was evaluated. The TED tested was a top-opening oval straight bar grid that was 104.1 cm (41 in) high by 81.3 cm (32 in) wide with a grid angle of 51.5°. The TED was exposed to 25 turtles with one capture observed. The median escape time was 36.5 s and ranged from 10 to 173 s (Table 8). Additionally, a small wild Kemp's ridley (*Lepidochelys kempii*) sea turtle was encountered, which passed through the 8.9 cm (3.5 in) bar spacing. The turtle was immediately removed from the codend and released. Divers estimated a carapace length of about 25.4 cm (10 in) to 30.5 cm (12 in) long.

Table 8. Top-opening, straight bar TED with double cover flap and 50.8 cm (20 in) overlap gear characteristics and results of small turtle testing.

Gear Characteristics	Description	Comments	Test Score	Escape Time
TED Type	Mid-size, straight bar, rod; 104 cm (41 in) H x 81.3 cm (32 in) W	12.7 cm (5 in) of extra overlap	1 capture 24 escapes	Mean = 57.1 s Median = 36.5 s Range = 10-173 s
Orientation	Top-opening			
Net type	Western Jib 15.2 m (50 ft)			
Door type/size	Wooden; 2.4 m (8 ft) x 101.6 cm (40 in)			
Installer	NMFS			
Floatation	None			
Opening	52.1 cm (20.5 in) L x 147.3 cm (58 in) W			
Flap	41.3 mm (1 5/8 in) poly, double cover; 50.8 cm (20 in) overlap; 48.3 cm (19 in) overhang			
Angle	51.5°			

Bottom-opening Straight Bar TED with Single Flap and Steep Angle (71^{0})

After examining the exclusion rate of a bottom-opening bent bar grid at a steep angle of 71^{o}, questions arose about how a straight bar grid installed at the same angle would perform. The bottom-opening curved bar grid captured four out of 25 turtles, which failed the small turtles test when compared to results of the second round of testing with the bottom-opening control. During testing in previous years, bent bar TEDs have consistently outperformed straight bar TEDs. This can be attributed to lower angle of the distal portion of the deflector bars, which allow small turtles to easily transition from the face of the grid out of the escape opening. For this test, a mid-sized oval grid with straight bars was used. The grid was constructed of aluminum rod and was 104.1 cm (41 in) tall by 81.3 cm (32 in) wide with a 180.3 cm (71 in) opening covered by a single flap. The flap was constructed of 41.3 mm (1 5/8 in) polyethylene, heat set, depth stretched webbing 90 meshes wide by 129.5 cm (51 in) long, which was sewn down 15.2 cm (6 in) beyond the posterior edge of the grid but extended 53.3 cm (21 in) beyond the grid.

This TED was exposed to ten turtles and captured nine (Table 9). Divers observed most turtles attempting to swim upward, searching for an escape route and eventually becoming pinned on the grid by water flow. Some of the turtles were able to spin around on the grid and head toward the escape opening, but were unable to push the flap open. The flap was sealed tightly due to the steep grid angle with the flap contacting the grid 15.2 cm (6 in) to 20.3 cm (8 in) from the posterior edge of the grid. This partial test illustrates the difference in turtle exclusion efficiency between bent and straight bar TEDs.

Table 9. Bottom-opening straight bar TED with a single flap installed at an angle of 71^0 gear characteristics and results of small turtle testing.

Gear Characteristics	Description	Comments	Test Score	Escape Time
TED Type	Mid-size, straight bar, rod; 104 cm (41 in) H x 81.3 cm (32 in) W	Steep Angle	9 captures 1 escape	Time = 43 s
Orientation	Bottom-opening			
Net type	Western Jib 15.2 m (50 ft)			
Door type/size	Wooden; 2.4 m (8 ft) x 101.6 cm (40 in)			
Installer	NMFS			
Floatation	1 Spongex top center; 22.9 cm (9 in) x 12.7 cm (5 in)			
Opening	66 cm (26 in) L x 182.9 cm (72 in) W			
Flap	41.3 mm (1 5/8 in) poly, single flap; 53.3 cm (21 in) overhang			
Angle	71°			

PHASE 4 – SHRIMP TRAWL BYCATCH REDUCTION DEVICE (BRD) EVALUATIONS

Background

In the southeastern United States, more and more stocks have been designated as overfished and bycatch reduction, particularly for the shrimp industry, has become a key management objective. In the Gulf of Mexico, a significant amount of industry and government cooperative research has been conducted to reduce shrimp trawl bycatch, particularly the bycatch of juvenile red snapper. The result has been several trawl modifications that significantly reduce finfish bycatch, while maintaining target shrimp catch. These Bycatch Reduction Devices (BRDs) have been required in the Gulf of Mexico shrimp fishery since 1998, but cooperative research efforts continue to seek out new designs that may further reduce bycatch. During 2012 testing, diver assisted evaluations and video documentation of several BRD and TED/BRD combinations were conducted.

Project Objectives

- Diver evaluations of a TED/BRD combination fabricated by Billy Burbank.
- Diver evaluations of the Composite Panel BRD, to adjust the fish deflector and investigate clogging potential with brown macroalgae, *Sargassum natans*.

Methods

Evaluations of BRDs were conducted aboard the *R/V Caretta* approximately 0.4 km (0.25 mi) off Shell Island, Florida at depths of 6.1 m (20 ft) to 9.1 m (30 ft) (Figure 1). A team of two divers were deployed during each evaluation, with one diver responsible for video documentation and the other recording water flow data and injecting dye into key areas of each BRD.

Results

As part of the shrimp trawl BRD project funded by the NMFS Bycatch Reduction and Engineering Program (BREP) program, the Harvesting Systems Unit provides assistance to researchers and fishers by making in situ video observations of prototype BRD designs. NOAA divers utilize video cameras, water flow meters, and environmentally safe dyes to document the functional configuration and water flow characteristics of BRD designs.

<u>Burbank TED/BRD</u>

Evaluations in 2012 included one industry prototype, the Burbank TED/BRD, which was similar in design to the original NMFS TED developed in the 1980s. The TED was installed in a bottom-opening configuration. Three panels of webbing were installed in the extension behind the TED grid to create reduced water flow areas designed to attract and congregate fish. There were also three escape openings, one for each webbing panel. Two of the openings were located on either side of the device adjacent to escape panels, while the third was located at the top of the device (Figure 13).

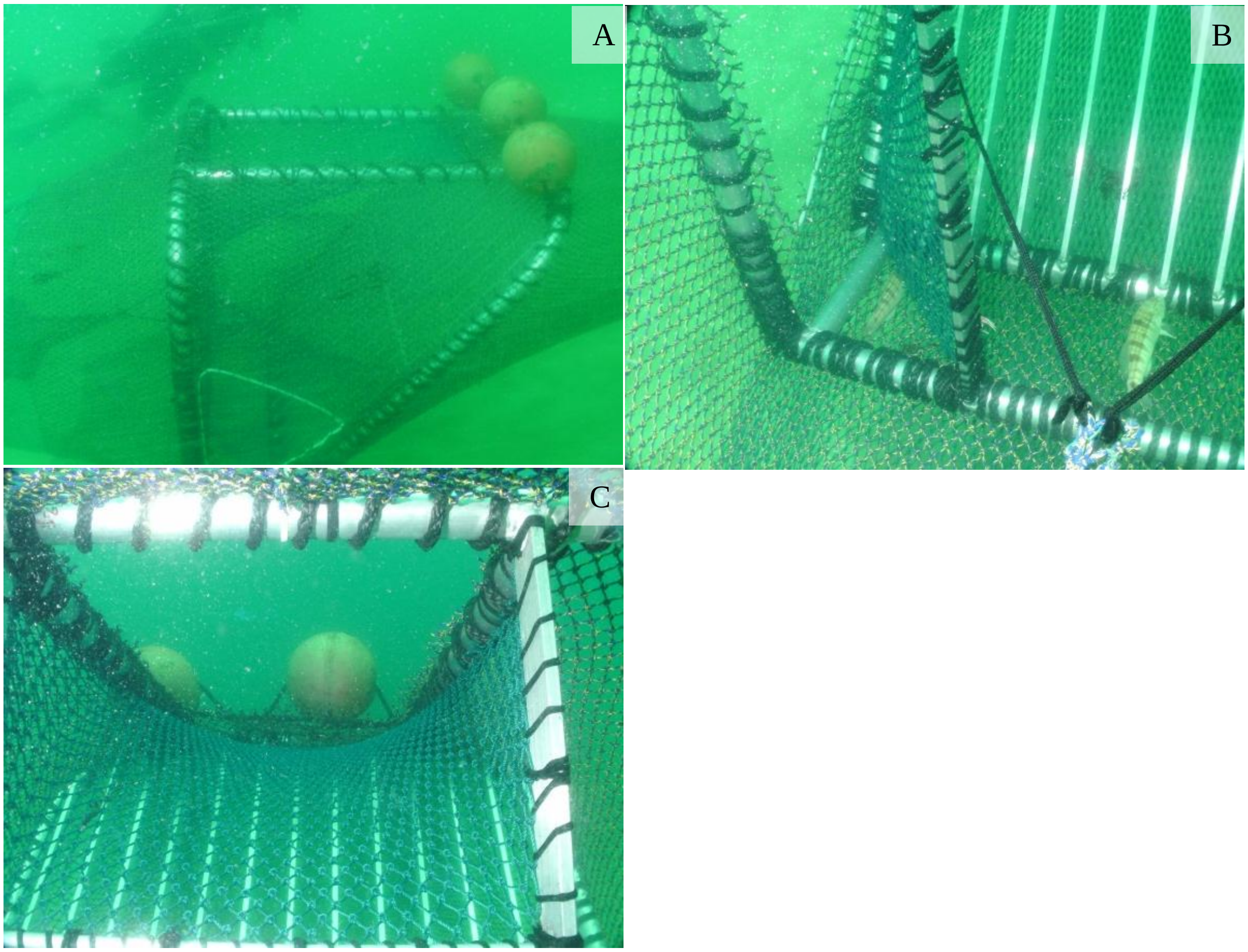

Figure 13. Starboard profile view of the Burbank TED/BRD (A). Inside view of the port side escape opening (B). Inside view of the top escape opening (C).

Composite Panel BRD

Harvesting Systems Unit divers also evaluated two configurations of fish deflector cones installed in the Composite Panel BRD. Currently, fish deflector cones are required to be attached to the trailing edge of the Composite Panel BRD by heavy twine, which forms a “V” behind the BRD (Figure 14A). However, reports from the industry indicate that this configuration is prone to clogging by seaweed and debris, causing shrimp loss. Divers evaluated an alternative configuration in which the fish deflector cone was attached by a single line to the center of the TED grid (Figure 14B). Each configuration was evaluated by inserting locally obtained brown macroalgae, *Sargassum natans*, into the trawl forward of the deflector cone.

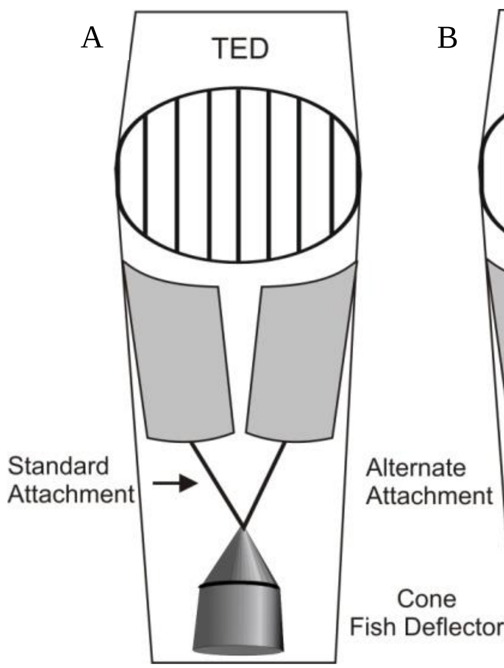

Figure 14. Diagram of the top view of the TED and Composite Panel BRD with a standard fish deflector cone attachment (A), and alternate cone attachment (B).

Testing confirmed industry reports that the standard deflector cone attachment configuration is problematic, in that the “V” shape of the attachment lines tended to catch and retain large quantities of seaweed, potentially blocking the passage of shrimp into the codend (Figure 15A). In addition, the cone also has top and bottom attachment lines with the bottom attachment also tending to clog, restricting passage of shrimp into the condend. The single attachment configuration was also prone to clogging (Figure 15B). However, the amount of clogging was less with the single forward attachment than the standard configuration. Also, the removal of the bottom attachment line allowed the flow of water to continue under the fish deflector cone, which is less likely to cause shrimp loss.

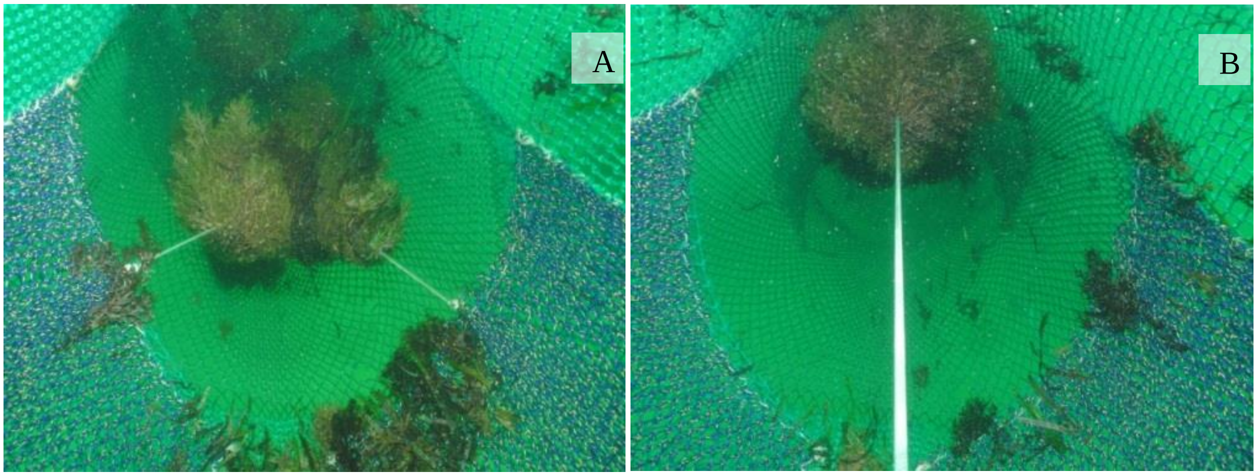

Figure 15. Photos showing the degree of clogging with the fish deflector cone standard "V" forward attachment (A), and the single line forward attachment (B).

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